BLM Technical Memorandum

Screening Assessment Approaches for Metals in Soil at BLM HazMat/AML Sites

September 2017 Update: Table 1 has been updated to reflect EPA's latest Regional Screening Level summary table values and toxicity updates (June 2017). The only metal whose screening levels changed from the previous version of this memorandum is uranium, which decreased an order of magnitude due to a new oral toxicity value recommended by EPA.

Introduction: The screening of chemicals present at a site constitutes the first phase of the assessment of human health and environmental risk. This paper discusses strategies and considerations for conducting a screening assessment, and describes a "multiple lines of evidence" approach to support site decision making.

At most BLM HazMat/AML sites, inorganics (metals and metalloids) are the primary concern, but many of the approaches in this document also applies to organic compounds. A screening level assessment typically consists of a comparison of site data with a risk-based concentration to evaluate whether a release has occurred and to get an initial understanding of the potential risks. Screening levels (SLs) are concentrations of chemicals in soil intended to be protective of human health and/or the environment under a defined exposure setting. SLs can be developed for all media, but are most commonly used at sites with soil contamination (or tailings). By their nature SLs are conservative (i.e., health protective) since they are acting in lieu of information gathered during a more detailed site investigation. Considerations for the development of SLs should include land use and habitat at the site, the presence and activities of human and ecological receptors, possible contaminant migration, and naturally occurring background concentrations. As a general rule, SLs are generic and do not take into account site-specific issues.

SLs are often used in the early phases of an environmental investigation program when only minimal data is available – for example, during the Preliminary Assessment and Site Inspection (PA/SI) phase. Data collected during more comprehensive site assessments, such as an Environmental Evaluation and Cost Analysis (EE/CA) or Remedial Investigation and Feasibility Study (RI/FS), may also be compared with SLs as part of a site-specific risk assessment. The data considered in a PA/SI screening assessment should include samples collected from site locations considered to be the most contaminated. The maximum detected chemical concentrations (max detects) may then be compared with SLs to get an initial understanding of the degree of potential risk present at the site. The approach of comparing max detects with conservative SLs tends to provide a worst-case portrait of potential risk. This worst-case evaluation tends to overestimate true risks and should be interpreted cautiously and in conjunction with the other site factors discussed in this memo.

Screening Basics: There are a number of assumptions inherent in SLs that need to be considered before conducting a site screening. In brief, the specific populations and receptors of interest, the primary pathways, and chemical toxicity all affect the appropriateness of an SL. For example, human health SLs can be developed for residents, workers, or recreational visitors, and may consider either cancer or noncancer endpoints. Alternatively, ecological SLs may be developed for soil dwelling organisms (e.g., invertebrates, small mammals), vegetation, birds, or herbivores. In general, SLs tend to be most appropriate for long-term, chronic exposure scenarios. In many cases at BLM sites, human exposures tend to be more occasional and short-term (e.g., a recreational hiker). Casual use of SLs should not replace an understanding of site setting and the development of a conceptual site model (CSM) that links chemical sources to potentially exposed receptors.

The results of a risk-based screening are typically presented as the ratio of the site concentration of a specific chemical to its respective health-protective screening value. This may be referred to as a numerical or quantitative screen. When the ratio (the "hazard quotient", or HQ, in risk assessment terms) exceeds one (1), that chemical is considered to pose a potential risk and should be evaluated further. If the max detect for a chemical is below its SL, it is often concluded that this chemical does not pose a risk and may be dropped from future consideration. Examples of widely used screening levels for chemicals in soil are presented in Table 1.

Screening can be made on a chemical-by-chemical as well as a media-specific basis. Most commonly, the max detect of a specific chemical is compared against a screening value for that same chemical. If the max detect is less than the SL, often it is concluded the chemical doesn't pose a risk and is not considered further. If the max detect for all chemicals are below their respective SLs, it is often concluded that the site soil doesn't pose a significant risk. Chemicals that exceed their respective SLs are termed "chemicals of potential concern" (COPCs) and it is generally considered that further action (i.e., more comprehensive investigation) is needed. If exceedances are substantial and the CSM suggests the exposures are ongoing, an emergency or time-critical removal action may be appropriate. More typically, however, additional data is collected to further evaluate how extensive the contamination and potential risk is before any remedial action is taken. It should be kept in mind that mine tailings and waste rock are not soil, although they are commonly evaluated as such in screening level assessments. Their physical and chemical attributes are different than actual soil, which may affect some risk assessment assumptions (e.g., bioavailability, which represents the amount of chemical actually absorbed into the bloodstream). The ecological habitat provided by tailings and waste rock may be of minimal value, since tailings are mostly devoid of nutrients and organic matter. As a general rule, it is not recommended that ecological SLs developed for soil be applied to tailings and waste.

Although screening level assessments are commonly mentioned in regulatory documents, there is not much available in the way of formal guidance. EPA's PA/SI, EE/CA, and RI/FS and Risk Assessment Guidance for Superfund (RAGS) should be reviewed if additional information is needed. In addition, some states have SLs available as guidance or written into regulation.

Background Concentrations: Screening against naturally occurring background concentrations is an important step at most AML sites. Background concentrations can vary significantly between locations, particularly in mineralized zones where mining is typically done. A background screen provides a different perspective from a risk-based screen; depending on the site setting and the chemical, the background concentration can be higher or lower than a risk-based screening value. Typically both a risk-based and a background screening comparison are conducted to determine which chemicals pose a potential risk above and beyond naturally occurring concentrations. A site may exceed risk-based SLs yet be below background levels; this should be taken into consideration when evaluating a screening assessment.

Table 2 presents a summary of representative background concentrations of naturally occurring metals in soil throughout the western US. These concentrations may not describe mineralized zones, however, and should only be used if site-specific values are not available. The data in Table 2 are provided as a general reference but are not meant to replace site-specific values. Background values are best used in combination with SLs to evaluate whether a release of hazardous substances has occurred at the site.

Using Screening Results: Screening level evaluations should be interpreted cautiously when making site management decisions. Screening assessments are usually based on limited site data; making informed decisions often requires that additional data be collected to better define the problem. It can be tempting to conduct a "quick and dirty" comparison of some data and conclude that the site does or doesn't pose an unacceptable risk. It should be noted that a screening level evaluation is only as useful as the site data (e.g., has a sample [or samples] been collected from the area of expected highest concentration?) and the appropriateness of the SL (e.g., a human health SL doesn't inform as to ecological risk). Screening levels are NOT default cleanup levels, and site decisions should not be based solely on exceedances of these levels.

The proper way to interpret a screening level assessment is by combining an understanding of possible human health risk, ecological habitat and exposure potential, site characteristics, contaminant migration potential, and background levels. An important initial step is developing a CSM, usually represented as a diagram that links contaminant source areas to human and ecological receptors via exposure and transport pathways (Figure 1).

Human Health Screening

The most widely used human health screening values are the Regional Screening Level (RSLs) developed by the US EPA for residential and industrial populations (http://www.epa.gov/region9/superfund/prg/). These values are very conservative (e.g., overly protective) for most BLM sites, since they assume more frequent and routine site exposure than typically occurs on BLM land. For example, the residential RSLs assume exposure to site soil for 350 days/year for 26 years and the industrial RSLs assume worker exposure for 225 days/year for 25 years. Although highly conservative for most BLM sites, EPA's RSLs can be useful in gaining an initial understanding of the magnitude of potential risk and at sites where off-site residents live in immediate proximity of the contamination. In addition to soil, EPA has developed RSLs for air, tapwater, and protection of groundwater. Some state health agencies

have also developed screening levels, but like EPA they only address residents and workers. EPA SLs for residential and industrial exposure are shown in Table 1.

Recreational visitors are the most common group of human receptors on BLM land. This is a broad category that can cover a range of possible activities, including camping, hiking, hunting, biking, ATV riding, horseback riding, etc., all with somewhat different exposure profiles. An example CSM for recreational visitor land use is shown in Figure 1. Most BLM land has no formal use or access restrictions, so conservative, yet realistic, assumptions must be made regarding the frequency of recreational use. BLM has developed a set of recreational SLs for metals most commonly found at AML sites. BLM's recreational SLs (Table 1) take into account the limited exposures associated with most recreational activities. The yearly recreational exposure frequency is assumed to be14 days/year, based on the assumption that individuals are unlikely to spend more time at an individual site on an annual basis. The exposure duration assumed for recreational visitors, 26 years, is the default exposure duration recommended by EPA for residents. It has been assumed that two years of the exposure occur as a child and 24 years as an adult; appropriate exposure parameters have been included in the calculations to account for these integrated age groups. The recreational RSLs were calculated using EPA's online screening level calculator. BLM will update the values in Table 1 periodically based on EPA's updates of toxicity values and exposure assumptions.

Ecological Screening

Terrestrial Receptors: A numerical ecological screening evaluation is not typically done in the initial phase of an environmental investigation. It is important to first identify habitat types present, possible receptors, and whether threatened or endangered (T&E) species may be present. This can be done through an investigation of site history and a literature search, and should be incorporated into the CSM. At most BLM mine sites, the ecological screening step will be more dependent on various qualitative endpoints, such as habitat, availability of food and shelter, and general ecological "attractiveness" of the site (such as proximity to waterways). Many BLM AML sites consist of tailings or waste rock piles, and provide little or no functional habitat to ecological receptors.

Ecological SLs for chemicals in soil for different receptors are available from EPA, US Fish and Wildlife, and other groups. These levels have many assumptions built into them, and should be considered only when the initial qualitative screening step indicates that that may be potentially significant exposures to sensitive receptors at the site. EPA ecological risk guidance notes a difference between potential impacts to individual organisms and population groups. An ecological screen at BLM mine sites needs to consider how widespread the site effects may be; impacts to receptors (real or calculated) assumed to be directly exposed to the site need to be considered in light of impacts to the local or regional population. In broad terms, common receptors are protected at the population level, while T&E species are protected at the individual organism level.

Conducting a quantitative ecological risk assessment (e.g., a "baseline" risk assessment) remains an option, should the screening step raise concerns over possible ecological risk. The ecological protective levels mentioned previously would be considered as part of a site-specific

risk assessment. This level of detail is only needed at a relatively small proportion of BLM HazMat/AML sites.

Aquatic Receptors: Some BLM mine sites directly impact aquatic habitat by draining into nearby wetlands, streams, or rivers. Tailings may have been dumped directly into waterways, may be slowing migrating over time, or acid mine drainage may be coming from an adit. Both contaminated surface water and sediments can adversely affect aquatic receptors, which are sensitive to the toxic effects of some metals. Sites that impact wetlands and waterways are generally of greater concern, due to potential widespread impact and the high toxicity of many metals to aquatic life.

Not all waterways run year round; many of the smaller streams near mine sites on BLM lands in the Western US are ephemeral in nature and are dry part of the year. This obviously limits the types of receptors that may be present. The CSM should determine whether aquatic or wetlands species need to be considered. Depending on the flow volume and regularity, ambient water quality criteria (AWQC) may be identified as "applicable or relevant and appropriate requirements", or ARARs.

Developing a "Multiple Lines of Evidence" Discussion for a Screening Assessment

A screening assessment should not be considered as a single step, rather it should assemble multiple lines of evidence that provide a more complete picture of contamination and risk at a site. Although every site has its unique characteristics, typically a screening analysis should consider the following factors as part of a multiple lines of evidence evaluation.

- Site characteristics: Location, proximity and access issues, historical activities
- Attractive nuisances: holes and adits, old equipment
- Contamination: distribution, concentration, types of chemicals, speciation
- Human health: signs of use, types of likely or possible use, numerical screening results
- Ecological: habitat types, presence of water, size of site, receptors, T&E species
- Groundwater and surface water: hydraulic connections, transport, leachability
- Background concentrations: mineralized zone vs. standard locations
- Offsite migration potential:

Figure 2 shows a schematic representation of how multiple lines of evidence may be combined to support decision making. It is not a fixed process with mandatory inputs; rather it is a flexible approach that combines a variety of relevant site information into an overall matrix that can provide the basis for informed decision making. The weighting of each line of evidence will vary depending on the quality and importance of the data. As the lines of evidence are developed, there are opportunities to collect additional information as project uncertainties are identified.

Taken collectively, the overall weight of evidence should allow the project manager to conclude whether the site is not likely to pose any risk or whether potential risk is present and the site should be evaluated further. The lines of evidence and their findings should be presented in the PA/SI (or other document) and used to support the overall conclusions of the investigation and help chart the path forward.

After the Screening Assessment

Screening assessments are most commonly used to evaluate sites and determine if they clearly pose minimal or no risk, may pose a potential risk, and those that clearly exceed acceptable risk levels. Future site activities may be developed based on the findings of the screening assessments. Sites with minimal risk may be candidates for a "no further action" determination; sites with potential risk may require a modest amount of additional information be collected to support decision making; and sites with high risk may be candidates for an EE/CA, an RI/FS, or more extensive intervention.

Initial site COPCs are typically identified in the screening assessment and may require further consideration. The lines of evidence discussion will help identify areas of uncertainty and data gaps that need to be addressed. Finally, screening levels may be useful as preliminary remediation goals, but should not automatically be considered as default cleanup values.

For additional information on screening assessments and risk assessments, please contact Doug Cox at the National Operations Center at dcox@blm.gov or 303-236-9451.

Table 1
Human Health Screening Levels (SLs) for Chemicals in Soil At BLM HazMat/AML Sites (mg/kg)

Chemical	BLM Recreational SL	EPA Residential SL	EPA Industrial SL
Aluminum (Al)	>1,000,000	77,000	>1,000,000
Antimony (Sb)	782	31	470
Arsenic (As)	30.6	0.68	3
Barium (Ba)	390,000	15,000	220,000
Beryllium (Be)	3,910	160	2,300
Cadmium (Cd)	1,780	71	980
Chromium (III) (Cr)	>1,000,000	120,000	>1,000,000
Cobalt (Co)	586	23	350
Copper (Cu)	78,200	3,100	47,000
Iron (Fe)	>1,000,000	55,000	820,000
Lead (Pb)	800[a]	400	800
Manganese (Mn)	46,700	1,800	26,000
Mercury (elemental) (Hg)[b]	271	11	46
Molybdenum (Mo)	9,780	390	5,800
Nickel (Ni)	39,000	1,500	22,000
Selenium (Se)	9,780	390	5,800
Silver (Ag)	9,780	390	5,800
Thallium (Tl)	19.6	0.78	12
Uranium (U)[c]	391	16	230
Vanadium (V)	9,850	390	5,800
Zinc (Zn)	587,000	23,000	350,000
Primary Exposure Assumptions	14 days/year, 26 years, adult/child	350 days/year, 26 years, adult/child	225 days/year, 25 years, adult

[a]The recreational SL for lead is based on EPA's industrial SL, which assumes regular and chronic exposure to soil, although not as frequently or extensively as the residential SL.

[b]Mercury is the only metal on the list whose SL is based on the inhalation pathway. EPA made some minor changes in their volatilization modeling in 2015 and the SL increased slightly. SLs for all populations may exceed the soil saturation concentration (Csat), an estimate of the concentration at which the soil pore water, pore air, and surface sorption sites are saturated. Above this theoretical threshold concentration, mercury may be present in free-phase within the soil matrix.

[c]Uranium screening values updated per changes in EPA's oral toxicity value.

Table 2
Representative Background Concentrations of Metals In Soils of the Western US (mg/kg)[a]

Chemical	Typical (Average)	High End (Maximum)
Aluminum (Al)	5,800	100,000
Antimony (Sb)	0.62	2.6
Arsenic (As)	7	97
Barium (Ba)	670	5,000
Beryllium (Be)	0.97	15
Cadmium (Ca)	< 1.0	11
Chromium (III) (Cr)	56	2000
Cobalt (Co)	9	50
Copper (Cu)	27	300
Iron (Fe)	26,000	> 100,000
Lead (Pb)	20	700
Manganese (Mn)	480	5,000
Mercury (Hg) (elemental)	0.065	4.6
Molybdenum (Mo)	1.1	7
Nickel (Ni)	19	700
Selenium (Se)	0.34	4.3
Silver (Ag)	0.5	5
Thallium (Tl)	9.8	31
Uranium (U)	2.7	7.9
Vanadium (V)	88	500
Zinc (Zn)	65	2,100

[a] Values are indicative of the range of naturally occurring soil concentrations in the western United States. Variations can occur from site to site. Concentrations in local mineralized zones may not be included.

Source: Elements in North American Soils, 2nd Ed. 2005.

Figure 1
Example of a Human Health Conceptual Site Model (CSM)

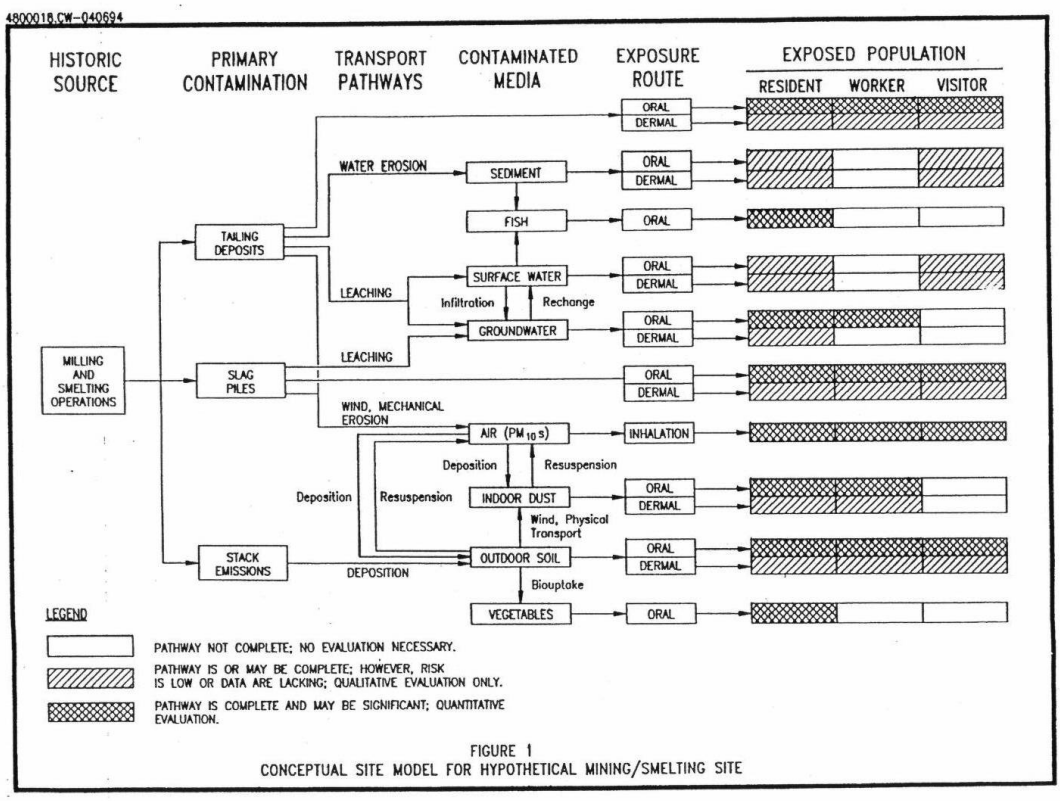

FIGURE 1
CONCEPTUAL SITE MODEL FOR HYPOTHETICAL MINING/SMELTING SITE
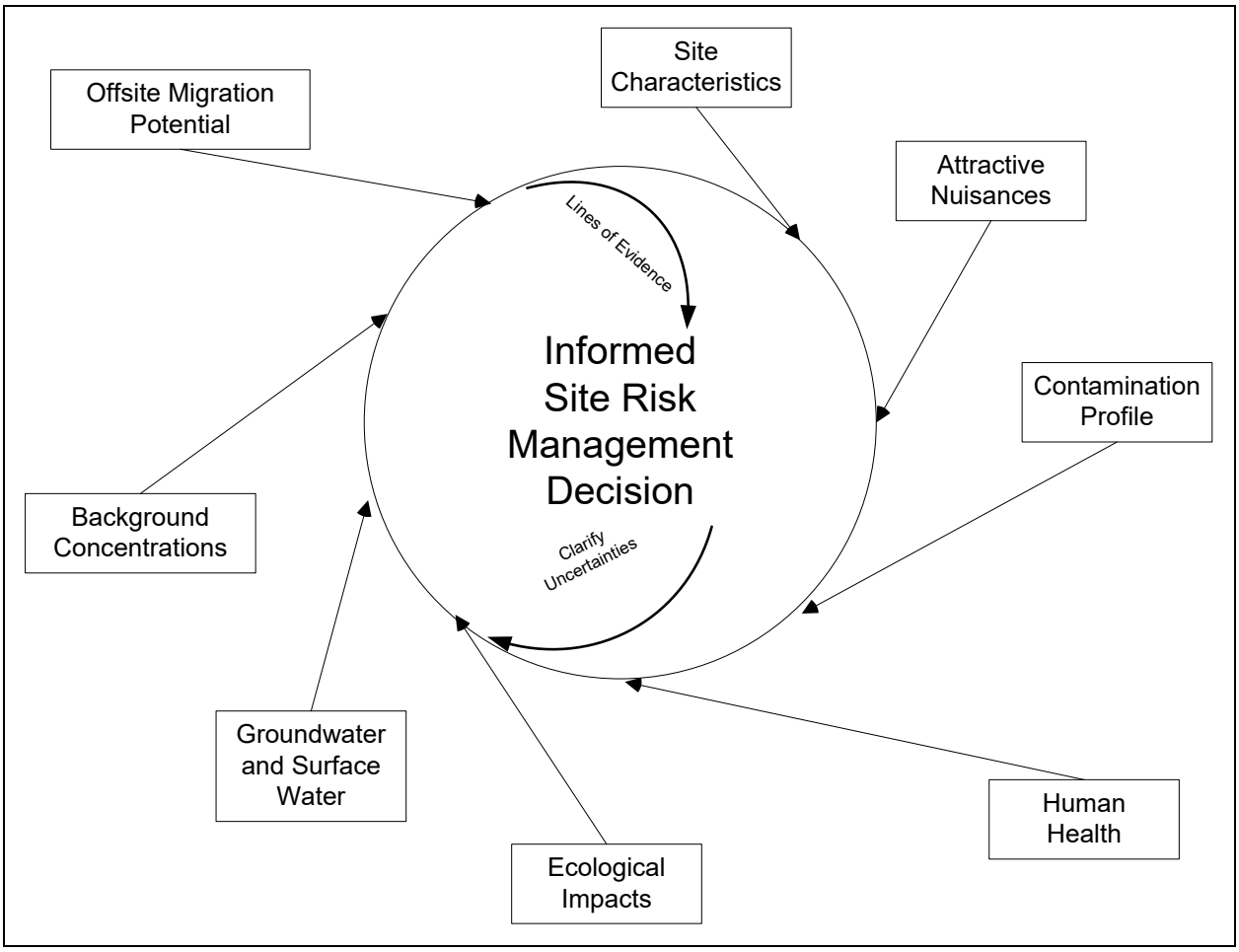
Figure 2
Using Multiple Lines of Evidence to Support a Screening Assessment